1. ISSUES, GOALS, AND OBJECTIVES

ISSUES

The United States is entering a period of change and uncertainty in the electricity sector. With the deregulation of electricity production, many unprecedented issues are challenging utilities, regulators, and the Federal Government. New technologies are altering the fuel choices made by utility planners. Environmental laws are causing the closure of older fossil-fuel plants, and many U.S. nuclear power plant owners are approaching a critical decision point as to whether their plants should be shutdown at or before their initial license period, or whether they should apply for a twenty-year extension on that license.

Reducing Greenhouse Gas Emissions

Environmental issues associated with the burning of fossil fuels, including global climate change, are increasing in importance. Power plants that burn fossil fuels to produce electricity emit sulfur oxides and "greenhouse gases" (GHG) such as carbon dioxide and nitrogen oxide, which are associated with global climate change. To reduce the GHG emissions that contribute to this problem, President Clinton presented his Climate Change Proposal on October 22, 1997. Key elements of this proposal included lowering current emission rates to 1990 levels by 2008-2012, and reducing emissions to below 1990 levels in the five-year period after 2012. The December 1997 Kyoto Protocol called for even more strict reductions, to 7% below 1990 levels by 2008-2012. Achieving 1990 levels or less between 2008 and 2012 will be a formidable task; emissions will have to be reduced by at least 35 percent from current, "business as usual" emission projections for this period. Accomplishing such reductions will require development of a comprehensive strategy that combines increased energy efficiency with greater use of cleaner, non-fossil energy sources.

Nuclear power plants do not emit GHG (Figure 1-1), so continuing their operation would help reduce GHG emissions. The November 5, 1997, report of the Energy Research and Development Panel of the President's Committee of Advisors on Science and Technology (PCAST) stated:

> "To reduce GHG emission and ensure that the United States has the capacity to achieve internationally agreed-to targets, it is important to pursue R&D that will help determine whether nuclear fission can become a stabilized and later an expanding contributor to this goal."

Economic and institutional factors including increasing regulatory costs and uncertainty, in combination with the upcoming deregulation of electric utilities, may lead to premature shutdown of operating nuclear plants in the United States. Forward-looking R&D can and should address many of the issues that could adversely impact continued nuclear plant operation, specifically nuclear waste, cost, reactor safety, and risk of proliferation. If successful, this R&D would help make fission power an acceptable option for providing electricity in the coming century. The Federal Government's role is to ensure that long-term problems with nuclear power are addressed

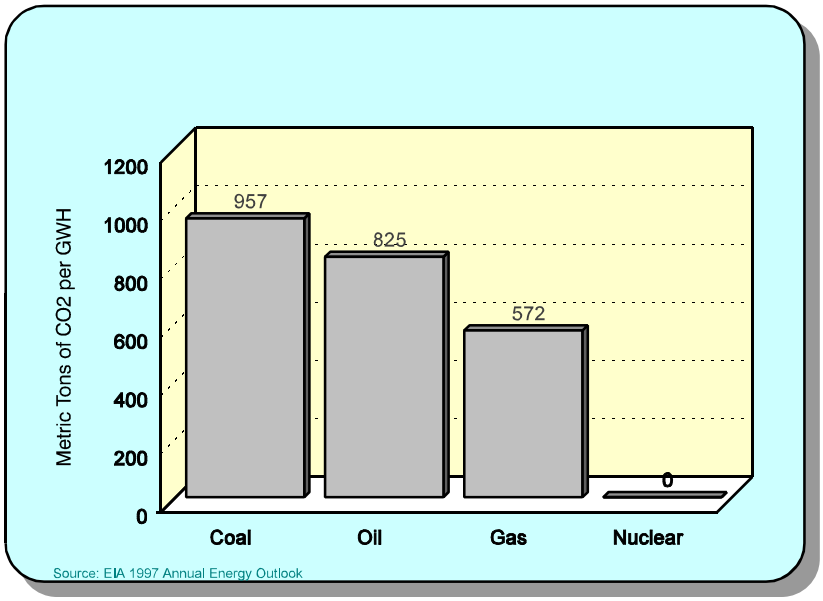

Figure 1-1. Carbon dioxide emissions from electricity generation

so that nuclear power can become a realistic and acceptable energy option. It is expected that nuclear energy, together with renewables and energy efficiency will be able to meet the President's emissions reduction targets.

This imperative for nuclear energy and the R&D to support its continued development is supported by two reports to Secretary of Energy Peña—one from a study produced by eleven national laboratories, *Technology Opportunities to Reduce U.S. Greenhouse Gas Emissions*, December 1997, and another by seven national laboratories, *Recommendations for a Department of Energy Nuclear Energy R&D Agenda*, December 4, 1997.

These reports agree that nuclear energy is essential to achieving recommended GHG emission reductions. (See Appendix B for more information on these reports.) The United States' use of nuclear power avoided over 1,700 million metric tons of carbon emissions in the period between 1973 and 1994 (See Figure 1-2). Another 2.5 billion metric tons of carbon emissions will be displaced by the time existing U.S. nuclear power plants complete their current licensed operating periods. By renewing most of the operating licenses of its current population of nuclear power plants, the U.S. could avoid an additional half billion metric tons of carbon emissions between now and 2035.

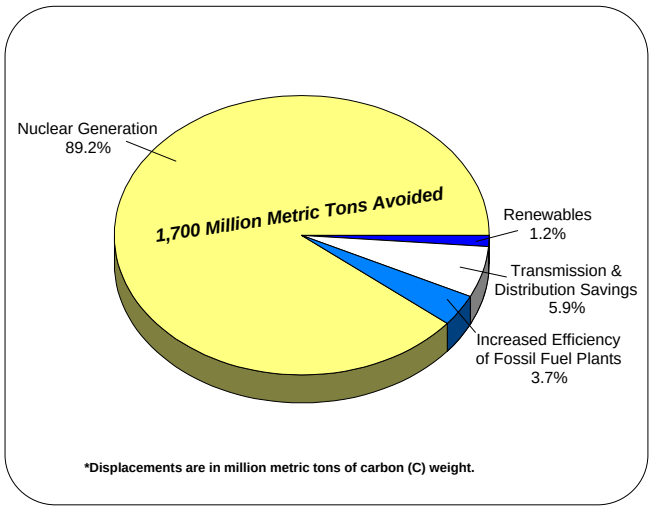

Figure 1-2. Nuclear Power Contribution to CO_2 Emission Reductions*
(CO_2 Emissions Avoided 1973-1994)

Energy Diversity, Supply, and Demand

The two studies cited above also agree on nuclear power's importance as a component of a balanced mix of electric energy resources (fossil, hydro, renewable, and nuclear). Today, 105 nuclear power plants produce over 650 billion kilowatt-hours of electricity annually, which is over 20 percent of the total U.S. electrical supply. Figure 1-3 shows the U.S. electricity mix. Figure 1-4 demonstrates that many states depend on nuclear energy for the majority of their

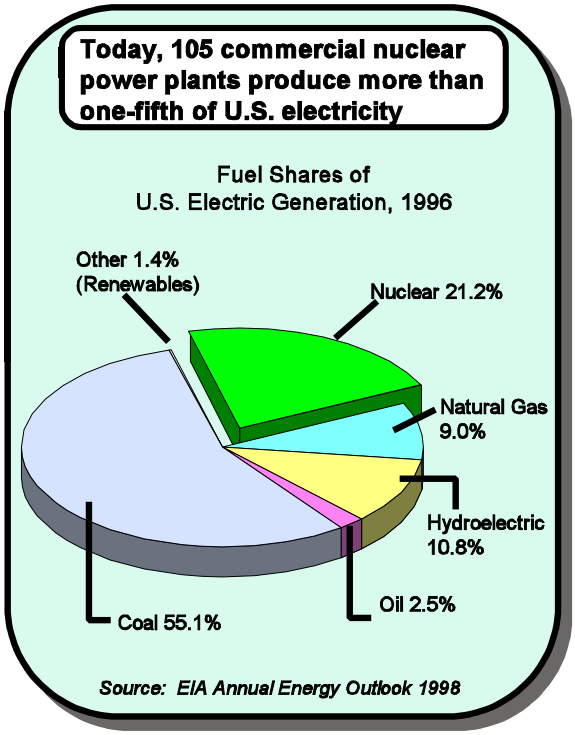

Figure 1-3. U.S. Electricity Mix

electricity. The role of nuclear power as part of a diverse, secure mix of electricity supply options is often demonstrated in times of crisis. In past years, when major floods hit the Midwest and extremely cold conditions occurred in the East, nuclear power plants in both regions continued operating while portions of the fossil fuel supply were interrupted. Decades ago, nuclear power plants provided critically needed electricity when Middle Eastern countries interrupted oil supplies to the United States.

In addition, electricity consumption in the United States continues to grow, making energy diversity even more important. The Department of Energy's Energy Information Administration (EIA) anticipates that, even with energy efficiency measures, U.S. electricity consumption will increase 1.4 percent each year through 2020 – the equivalent of building seven new large 1000-megawatt power plants every year. During this same period, the EIA projects approximately 127,000 megawatts of existing electricity generating capacity will be retired because of age and economics. This represents 17 percent of the United States' present electricity generating capacity. The reduction in baseload nuclear generating capacity will have a significant impact between 2010 and 2020, as illustrated in Figure 1-5, when EIA projects approximately 30,000 megawatts or nearly one-third of the existing U.S. nuclear generating capacity will retire. As a result, the EIA estimates the United States must build over 1,000 new fossil fuel generating plants by 2020 to meet growth in demand and offset plant retirements. Building these plants would require a huge economic investment in new baseload generating capacity during the first two decades of the next century.

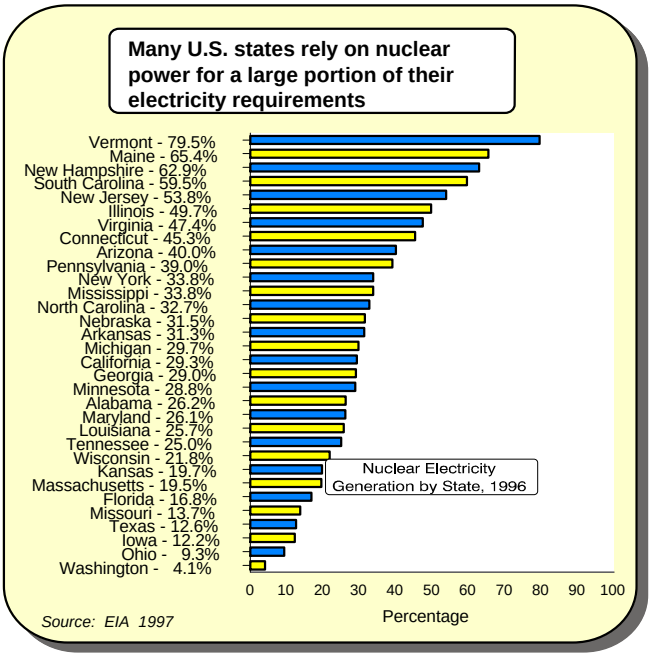

Figure 1-4. Percentage by state of electricity generation from nuclear energy

Continued operation of its existing nuclear power plants is a vital part of the U.S. energy diversity strategy (see Figure 1-3). Nuclear power plants have operated safely and reliably in the United States for decades and are capable of continuing to do so for many decades to come. Continuing the operation of existing nuclear plants through their original license term and a renewed license term of 20 additional years would delay the need to build more baseload fossil power plants, thus avoiding substantial carbon emissions.

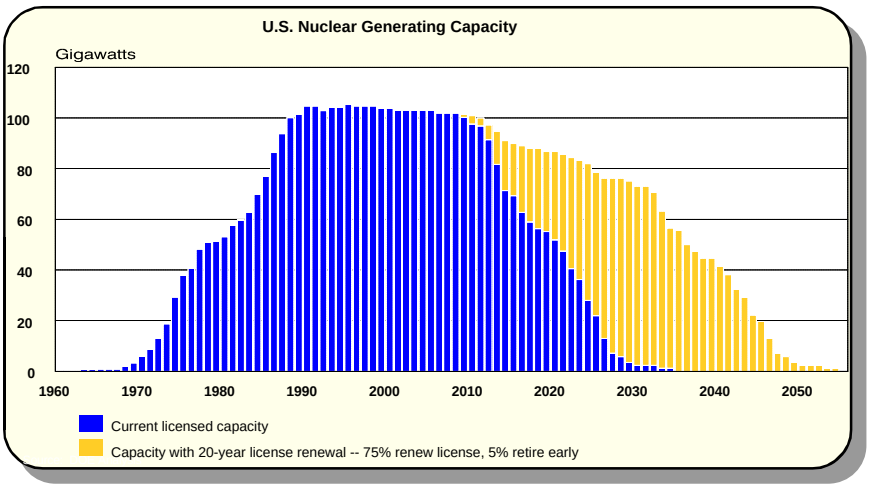

Figure 1-5. U.S. Nuclear generating capacity with and without license renewal

Utility Deregulation and Economics

The uncertainties of the present have put this important energy source at risk in the United States. Many utilities wonder what impact deregulation of the electric industry – with its apparent emphasis on near-term economic payoff – will have on the operation of their nuclear plants. Also, the continuing issue related to the management of commercial spent nuclear fuel creates an uncertainty and public controversy that could influence utility decisions with respect to continued operation of these nuclear power plants.

Economically, nuclear plants present complex issues for state regulators and Federal policy makers in a competitive electricity sector. Many nuclear plants suffer from large initial construction debt that must be recovered. The question of who will pay these debts and other utility-borne potentially "stranded costs" is a central issue of the electric restructuring debate. If those costs are treated as has been done in California, the price of nuclear power will be based primarily on production (fuel plus operating and maintenance) costs. The average production costs of nuclear electric power generation are competitive with the costs of producing electricity from oil, coal, and natural gas. In 1995, six out of every 10 nuclear power plants generated electricity at under 2 cents per kilowatt-hour. Once laws and regulations guiding the restructuring of the electricity sector are finalized and implemented throughout the nation, efficient and well-run nuclear power plants are likely to continue operating – if a stable and predictable license renewal process is in place, and if technical issues associated with aging do not impact these economics.

Regulatory Process

The potential for computer technology, computer-aided design, state-of-the-art I&C, advanced information management systems, new high-strength and corrosion-resistant materials, etc., could

lead to a virtual revolution in what is possible for new power generating technologies, especially nuclear. However, unlike most high technology energy sources, nuclear energy needs to demonstrate the viability of new technologies in a unique regulatory environment often resistant to change – even beneficial and safety-enhancing change – without requiring industry to undergo an extraordinarily long and costly process. In contrast, many of the technology improvements developed through nuclear energy R&D have been applied successfully and more rapidly to improve fossil fuel generation, where the unique regulatory environment that currently exists for nuclear power was not a factor. The electric utility industry believes that the current regulatory process is much more costly than counterpart systems in other developed nations and in other U.S. regulatory systems, and must be simplified to function effectively under economic deregulation. Exploiting the advantages of modern technology is part of the change that is needed. The new technologies that are essential to the future of nuclear power are ones that will reduce the costs of nuclear energy production and regulation. These include cost-effective aging effects management, digital Instrumentation and Control (I&C), computerized plant configuration management, and Probabilistic Safety Assessment (PSA) techniques in support of risk-based regulation. In this regulatory context, it is appropriate that the government participate significantly in the R&D program, particularly where government can help remove barriers to new technology, and where it can provide unique technical resources that enable nuclear energy to reach its full potential.

Plant License Expirations

The U.S. is at a critical juncture, however, with regard to the continued operation of its nuclear power plants. Licenses for U.S. nuclear power plants will begin to expire in large numbers in 2010; 13 plants representing some 11,700 MWe will go off-line in 2014 alone. Although plants are licensed to operate for forty years, it appears unlikely that many U.S. nuclear power plants will operate much beyond 30 years, since the ability to make and recover investments in the plant and remain competitive in a deregulated electricity market diminishes rapidly in their last ten years of licensed life. Faced with social, regulatory, and economic uncertainties, some utilities already have exercised their option to close their nuclear facilities well before their license expiration date. This trend has resulted in a loss of approximately 6,000 megawatts of U.S. generating capacity in the past eight years. Unless reversed by positive near-term action, this trend is expected to continue and could potentially accelerate as the uncertainties of deregulation come into play. The necessary near-term actions include demonstrating a viable and efficient license renewal process, and addressing critical aging and generation optimization issues that are important to safe, economic continued operation.

While decisions on specific plants will be made by utility executives, continuing the operation of a majority of the nation's nuclear power plants clearly serves several vital national interests. The nuclear utility industry estimates that significant lead times (~10 years) will be required to achieve license renewal. This is the time required to compile necessary technical and operating performance information, resolve associated technical issues, and navigate an untried Nuclear Regulatory Commission (NRC) license renewal process. Although industry and DOE believe that most of the generic technical issues for license renewal have been adequately addressed, resolution of these generic technical issues to the satisfaction of the NRC will require industry and the Department to be prepared with additional data and new aging management technologies to provide the necessary regulatory and investor confidence in reliable operation through the

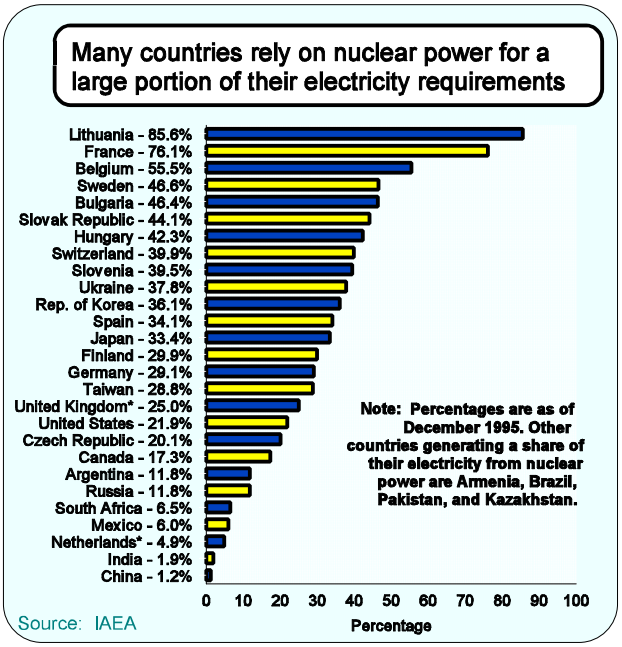

Figure 1-6. Share of nuclear energy electricity generation, by country

extended license term. This will require material- and age-related research and technology demonstrations to support utilities selected as early candidates for license renewal. To avoid the projected loss of 30,000 megawatts by 2020, work must begin today to address these technical and research and development (R&D) issues.

International Leadership in Nuclear Technology

A final issue of strategic national interest is the expanding role that nuclear energy will play in the world economy. As shown in Figure 1-6, many countries currently rely heavily on nuclear energy; and, as shown in Figure 1-7, the use of nuclear power internationally is projected to continue to expand over the next 50 years. This growth will be most dominant in the developing countries, where the desire is strong for safe, high performance nuclear technology. The expected increased use of nuclear energy by the developing world will help moderate the increased emission of greenhouse gases that will accompany the expansion of economic activity. For industrialized countries with currently operating nuclear plants, the technology developed under this strategic plan will be of direct use for those overseas nuclear plants and help improve their safety, as they age and require new technology and aging management solutions. Thus, this Strategic Plan contributes to US leadership in nuclear safety, non-proliferation, environmentally superior energy technologies, and U.S. strength in global markets.

Technical Issues

The goals, objectives, and R&D projects proposed by this Plan were developed as a direct response to technical issues arising from the operation of nuclear power plants. These technical issues involve the degradation of materials in various nuclear plant components and structures, a desire to improve and optimize the operation and output of the existing nuclear plants, and the need to demonstrate an untried federal regulatory process.

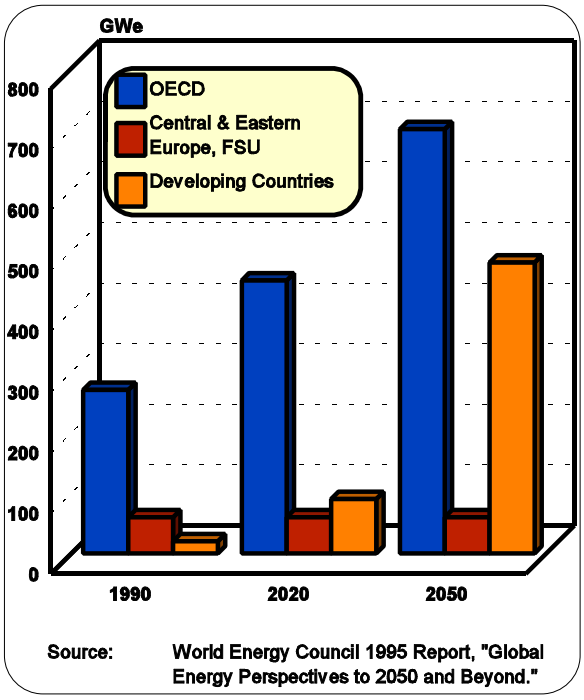

Figure 1-7. Projected worldwide growth of nuclear energy to 2050

Component and structure material degradation occurs in nuclear plants as a result of long-term operation and exposure of materials to harsh environmental conditions. Material degradation occurs in harsh conditions that include radiation and elevated temperature and pressure environments in the reactor pressure vessel, reactor internals, steam generator tubes, system piping, structures, and electrical cables. These components incur degradation over time in the form of corrosion, heat and stress related fatigue and cracking, and reductions in fracture toughness due to neutron irradiation and thermal embrittlement. These material degradation mechanisms have been anticipated but are becoming evident due to the age of operating nuclear plants. Research will provide a better understanding of each degradation mechanism and how it occurs, enabling development of cost effective aging management strategies which will provide capabilities to easily prevent, detect or repair the degradation.

Current nuclear plants were designed and are operating with technology developed over twenty-five years ago. As these nuclear plants continue to age, components and parts age or become obsolete, introducing inefficiencies or added costs. There have been significant technology advancements over the past twenty-five years that are applicable to power generation, particularly in computers, communications, materials, artificial intelligence and digital electronics, providing more accurate, reliable and cost-effective technologies. Many of these advancements came from our Nation's defense and space research programs. Further research and technology developments will produce new technology applications that will make nuclear plant operation and maintenance processes more economical and improve overall plant output. These technology advancements include areas such as digital instrumentation systems, advanced sensor technology and advanced monitoring, diagnostics and control systems. Other advancements in high efficiency nuclear fuel technology and options to improve plant capacity factors are possible. Demonstrations of technology performance will be an integral part of this research and development effort in order to achieve regulatory acceptance of these new technologies for use in existing nuclear plants.

GOALS & OBJECTIVES

The strategic guidance for the development of this Joint R&D Plan was obtained from the market assessment of commercial nuclear energy technology requirements that support critical national needs. For the purpose of framing this strategic R&D plan, a set of Strategic Goals and Objectives has been drawn directly from the goals and objectives of two recently published DOE and EPRI Strategic Plans (Figure 1-8). The goals and objectives in these two Strategic Plans, the *Nuclear Energy R&D Strategic Plan in Support of National Nuclear Energy Needs* (June 1997, EPRI), and *The U.S. Department of Energy Strategic Plan* (Sept. 1997, DOE), are consistent with the major national nuclear policy guidance provided in the Atomic Energy Act, as amended, and the Energy Policy Act of 1992. As shown in Figure 1-8, a number of recent federal and industry studies of energy R&D needs were considered in the development of this Plan[1]. Each of these studies is described in Appendix B, with emphasis on the recommended contributions nuclear energy R&D can have on the future energy supply of the nation. Appendix C provides more detail on the R&D

[1]See References 1 through 7 in Appendix A, and Appendix B.

goals and objectives from the DOE and EPRI Strategic Plans, from which the goals and objectives for this more narrowly focused Strategic Plan were extracted.

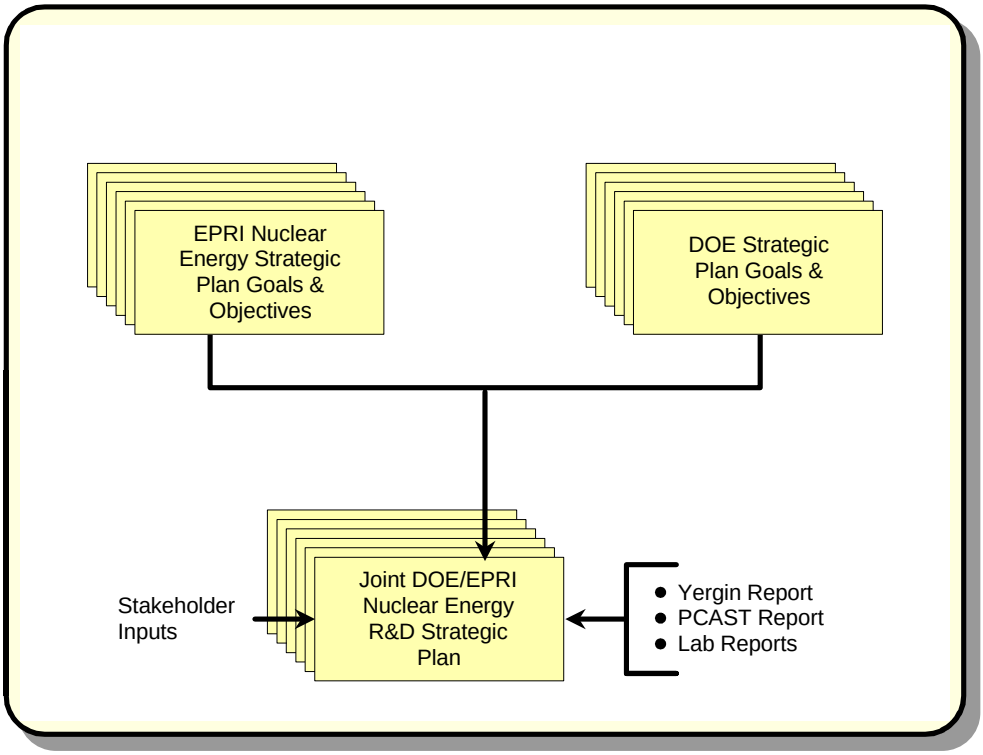

Figure 1-8. Inputs to Joint DOE-EPRI Strategic Plan

These goals and objectives are organized into three program elements, each with a number of R&D tasks. Thus, the R&D task areas included in this Plan are directed to the specific technology needs that follow from this goal-based review of national requirements, principally those goals related to ensuring the cost-effective operation and life cycle management of currently operating nuclear plants. In general, this R&D is focused on near-term and medium-term technology development to conform to the recommendations of PCAST. The goals and objectives within the scope of this Strategic Plan address the technology issues and opportunities that face existing U.S. nuclear power plants, especially issues that may prevent continued operation.

Goal 1: Ensure current nuclear plants can continue to deliver adequate and affordable energy supplies beyond their initial 40 year license period, by providing a strong technical basis for long-term operation, via stable and efficient license renewal programs, by resolving open issues related to aging mechanisms, and by applying new technologies to improve the cost-effectiveness and predictability of the life cycle management process.

R&D Objectives

1. Conduct sufficient R&D on nuclear plant aging phenomena so as to provide utilities and NRC with the information and methods needed to measure, predict and control long-term material conditions. Develop and demonstrate effective methods for aging assessment and management.

2. Apply R&D results to four generic plant licensing demonstrations (one for each NSSS vendor design), addressing all technology solutions to aging issues, and testing License Renewal Rule technical requirements for generic application to other candidate plants.

3. Maintain and expand critical materials research in order to be prepared for new issues related to the performance of existing plant equipment (particularly, long-lived, passive components and structures), and to be prepared with repair and replacement options based on technologies that have been tested and approved by NRC, ASME, etc.

4. Resolve new technical issues that might arise during NRC review of initial license renewal applications.

Goal 2: Ensure current nuclear plants can continue to deliver adequate and affordable energy supplies by continuing to develop and apply the best technology to enhance nuclear generation capability, efficiency, and productivity.

R&D Objectives

1. Improve nuclear power plant reliability and availability to increase the capacity factor of existing nuclear power plants from the 1996 average of 76 percent to 85 percent by 2010. (DOE Strategic Plan Objective 2, Strategy 7)

2. Develop new state-of-the-art technologies that will enable all nuclear energy plants to achieve economic competitiveness. Primary focus should be on advanced I&C, advanced Information management systems, advanced man-machine interface and human factors engineering, and advanced inspection/repair technologies.

3. Develop new technologies and analytic methods that can allow safe, reliable power up-rating of existing plants, through reduction in administrative limits that do not compromise safety margins.

4. Assure the continued availability of reliable and economic nuclear fuel. This includes optimizing the economics and performance of current nuclear fuel designs, and developing advanced LWR fuel cycle designs that can achieve higher burnup/longer life, greater fuel utilization and higher reliability. (see DOE Strategic Plan Objective 2, Strategy 7)

Strategic Plan Elements

The goals and objectives of this Joint DOE/EPRI Strategic R&D Plan were evaluated to establish the task areas and individual tasks which need to be performed in order to achieve the strategic goals of this plan. The tasks, once identified, were grouped into three sections, one for each of the following plan elements:

Plant Aging: Conduct R&D to understand, characterize, and manage or mitigate effects of plant aging on key reactor components, such as reactor pressure vessels and vessel internals, steam generators, electric cables, primary system piping, and safety-related concrete structures.

License Renewal:	Develop technologies to reduce the costs and regulatory uncertainties for license renewal, including adequate demonstrations of the license renewal process.
Generation Optimization:	Develop and demonstrate technologies to optimize the power output from existing nuclear power plants, e.g., develop NRC-licensable replacements for outdated analog instrumentation and controls, self-checking/calibrating sensors, fiber optic technology, and on-line diagnostics and information management systems.

These two goals contain both short and medium-term R&D objectives. In general, the short-term objectives (i.e., < 5 years) are primarily the responsibility of industry. The medium term objectives (i.e., 5-20 years) are typically shared between industry and government. These goals correspond generally to program elements (chapters) in this Joint R&D Strategic Plan, with Goal 1 mapping to chapters 3 and 4, and Goal 2 mapping to chapter 5.

It is important to clarify why the R&D for license renewal, which consists primarily of a demonstration of an unproven technical regulatory process, is as important as R&D on aging effects and generation optimization as a priority for DOE funding. First, from a national strategic perspective, demonstration of a viable and efficient process is a very high priority nuclear R&D goal. This is the measure of success for all the R&D and improved process and rulemaking efforts that have occurred over the last decade, and the measure of success of future R&D and regulatory process improvement tasks. These demonstrations will enable the nation to realize the environmental and economic benefits of continued safe, reliable and cost-effective operation of a majority of current operating plants.

Further, without a viable and efficient process that will allow long term power generation planning to count on a cost effective option for license renewal, the reality is that most utilities will opt to shut their nuclear plants down at or prior to the initial license date. Under deregulation, power generation is a business, just like any other business, where decisions are made based on a measure of risks and profits. Today, the option to renew a license is seen as a relatively high-risk choice, because of the high uncertainty associated with the process. The role of the federal government in technology R&D is to address such high risk needs, especially where there is a high national interest at stake – in this case, emission-free power generation. Whereas utilities must make license renewal decisions based solely on economics, DOE can take into account the higher national interests. What Chapter 4 sets forth is a series of generic license renewal demonstrations, one for each of the four Nuclear Steam Supply Systems operating in the U.S. (designs by Westinghouse, General Electric, ABB-Combustion Engineering, and B&W-Framatome), each with unique technical and process issues that must be resolved for plants within that group to demonstrate a viable process.

The R&D projects described in chapters 3 and 5 have significant value to industry and the national interest even without license renewal, but the value of that national investment is enhanced as the number of plants that apply that technology for an extended license term increases. Thus all three

chapters that follow are important to each other and to the goals in Chapter 1, because each contributes an essential element to achieving these goals.

Future R&D Goals

It should be noted that longer term goals for nuclear energy, primarily related to building new plants, also derive from the DOE and EPRI strategic plans and from the "U.S. Nuclear Energy Industry Strategic Plan for Building New Nuclear Power Plants", but are not within the current scope of this Joint Strategic Plan. The primary reason for this is lack of either industry or government resources to pursue these goals at the present time. The option exists to include these goals within the scope of this Strategic Plan in the future, but this initial joint strategic plan contains no R&D tasks to support these future goals.

Future goal: Provide competitive nuclear energy generation options to meet medium term (5 to 20 years) requirements for adequate and affordable baseload capacity as needs develop.

R&D Objectives:

1. Maintain a viable nuclear option for future, carbon-free baseload electricity through cooperative technical development activities with U.S. electric industry that would facilitate a U.S. order of an advanced nuclear power plant by 2010 (DOE Strategic Plan Objective 2, Strategy 8).

2. Maintain effective, ongoing processes for transfer and application of technologies developed for advanced reactors to meet current plant needs, and for application of solutions developed for current plant issues to enhance future plant options (EPRI Corollary Goal #13).

3. Complete design certification engineering of ALWR designs (AP600 remains) and obtain acceptable design certifications (rule-makings) for each design. "Acceptable" in this context means that the design is acceptable to the NRC and that the rule under which the design is to be implemented is judged to be practical and cost-effective by industry (Strategic Plan for Building New Nuclear Power Plants, Building Blocks 2 and 4).

4. Complete First-of-a-Kind Engineering (FOAKE) for the two ALWR designs selected for this additional work (ABWR and AP600) (Strategic Plan for Building New Nuclear Power Plants, Building Block 6).

    - Develop new technologies that improve the fabrication and construction processes for nuclear components and that reduce the construction times and capital costs of nuclear plants.

- Evaluate options for further advances in the ALWR designs in the current ALWR program, to meet future contingencies. Possible contingencies that could require a commitment to more advanced ALWR developments include:

  - C Future market requirements for passive ALWRs with a smaller or larger than 600 MWe plant electrical output

  - C Innovations to improve ALWR electrical production efficiencies.

Future Goal: Support U.S. energy, environmental, and economic interests in global markets. (DOE Strategic Plan Objective # 4).

R&D objectives :

1. Apply the U.S. technology used to address the above goals to foster increased international trade in superior U.S. nuclear technologies (EPRI Corollary Goal # 14).

2. Cooperate with foreign governments and international institutions to develop open energy markets, and facilitate the adoption and export of clean, safe, and efficient energy technologies and energy services. (DOE Objective 4, Strategy 2). Specifically, support implementation of U.S. government agreements with Asian-Pacific countries that open enhanced market opportunities for U.S. nuclear industrial suppliers, enabling them to exchange information and export U.S. light water reactor technology and services.

SUMMARY

The impediments to sustaining operation of existing nuclear plants and achieving large-scale application of license renewal in the U.S. fall into three broad categories: technical (e.g., uncertainty over aging effects), economic (technology competitiveness), and regulatory (uncertainty over the license renewal process and its stability and predictability over time). All three areas are important, each is essential to achieving large-scale application of license renewal, and each is amenable and ripe for R&D investment. The urgency of addressing all three areas at this time is clear from two perspectives. First, the international environmental goals for reduction of greenhouse gas emissions agreed to at the Kyoto summit are aggressive, and require technology responses to be accelerated in order to meet such commitments. Second, the total time required to achieve regulatory approval for license renewal has been estimated by industry to be ten years or more. Given current license term expiration dates for most older plants, the need is urgent to demonstrate that an efficient and predictable process exists, so that utilities can include this option in their long-term generation planning process.

The challenge that DOE and EPRI have undertaken is to review carefully prior individual plans for the nation's nuclear energy R&D programs; and to jointly develop a single, comprehensive nuclear energy R&D strategic plan that is fully supported by the leadership of both organizations and by the owners of nuclear plants, that meets the intent of the PCAST recommendations, and that will

be understood and supported by the Congressional leadership responsible for energy R&D programs. This joint strategic plan, in conjunction with DOE's initiative for long-term R&D projects (Nuclear Energy Research Initiative, discussed in Section 2), meets that challenge. To implement this plan, DOE and EPRI will need to enlist the input and support of the nation's electric utilities, national laboratories, the colleges and universities with nuclear research programs, and the many elements of the nuclear industry with expertise in nuclear energy R&D. They will also need to interact with NRC to ensure that research is coordinated, not duplicated, and achieves the goals of this Plan.

The electric utility industry leadership and the national policy makers with planning or budgetary responsibility for nuclear energy R&D are the primary audience for this Plan. Both generally support preserving the strategic and economic advantages of a mix of energy supply options competing on an even playing field in a free market. Both are acutely aware of the need for reducing the cost and increasing the market value of R&D. Accordingly, both share common objectives, and this encourages joint planning and cost-sharing – where appropriate – of R&D being transitioned to the private sector. Government and industry recognize that they must work in partnership to effectively implement any long-range national energy strategy.

The long-term need for nuclear energy and a future perspective are discussed in Appendix E.